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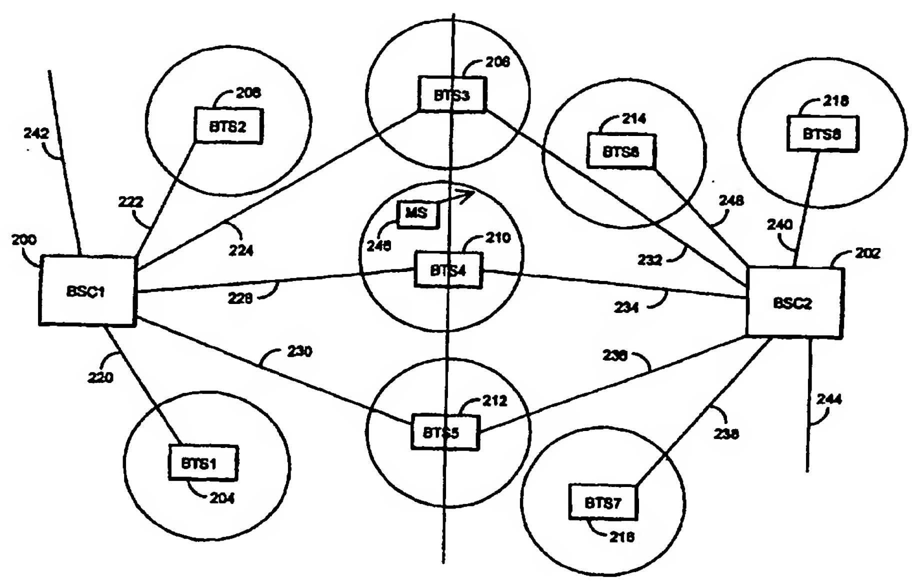

(57) Abstract

The invention relates to a method for carrying out a handoff, and a cellular radio system employing code division multiple access and comprising at least one base station in each cell, and a group of base station controllers BSC to each of which is coupled at least one base station. The BSC and the base stations coupled thereto constitute a base station system BSS. The BSCs control the use of radio resources of the base stations coupled to them. In order to facilitate a handoff, the base stations located at the border of two or more BSSs are connected to at least two BSCs which control the base station.

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Cellular radio system and a method for performing handoff

Field of the Invention

The present invention relates to cellular radio systems employing code division multiple access and comprising at least one base station in each cell, and a group of base station controllers (BSC) to each of which is coupled at least one base station, the BSC and the base stations coupled thereto constituting a base station system (BSS), and the BSCs controlling the use of radio resources of the base stations coupled to them. The invention particularly aims at a new method for carrying out a handoff of a subscriber terminal equipment between two different BSSs.

Related Art

A CDMA (Code Division Multiple Access) system is a multiple access method which is based on spread spectrum technology and whose application in cellular radio systems has lately been initiated along with the earlier FDMA (Frequency Division Multiple Access) and TDMA (Time Division Multiple Access) technologies. The CDMA technology has several advantages over the earlier methods, such as spectral efficiency and simple frequency planning.

In a CDMA method, the narrow-band data signal of the user is multiplied by a spreading code of much wider bandwidth to a relatively wide band. In the known experimental systems, the bandwidths used include, for example, 1.25 MHz, 10 MHz and 25 MHz. In the multiplying process, the data signal spreads to the whole band used. All users transmit simultaneously by using the same frequency band. A separate spreading code is employed for each connection between a base station and a mobile station, and the signals from the users can be

identified from one another in the receivers on the basis of the spreading code of each connection.

Matched filters or correlators in the receivers are synchronized with the desired signal, which is identified on the basis of the spreading code. The data signal is returned in the receiver onto the original band by multiplying it by the same spreading code as in the transmission phase. The signals which have been multiplied by some other spreading code neither correlate nor return to the narrow band in an ideal case. They thus appear as noise from the point of view of the desired signal. An attempt is made for choosing the spreading codes so that they are mutually orthogonal, i.e. they do not correlate with each other.

In a typical cellular radio environment, signals between a base station and a mobile station travel by several different paths between the transmitter and the receiver. This multipath propagation is mainly caused by signals reflecting from the surrounding surfaces. Signals that have travelled through different paths arrive at the receiver at different times due to different delays in the propagation time.

Generally speaking, the spreading codes are not orthogonal with all the delay values. Therefore, signals delayed in different ways cause interference in signal detection. The interference caused by the users to one another is referred to as multiple access interference.

A base station transmits to all the mobile stations within its service area by using the same frequency band. The same frequency band is typically in use in adjacent cells as well. To minimize multiple access interference within one cell, the aim is to choose the spreading codes employed by a base station to be mutually orthogonal.

In CDMA cellular radio systems it is possible to use a so-called pilot channel. The pilot channel is a data unmodulated signal which thus contains no data information and which is transmitted with a specific spreading code. The pilot channel is transmitted by using the same frequency band which contains the actual traffic channels, from which the pilot channel can only be identified on the basis of the spreading code. A pilot channel is used, for example, in power measurements and in generating a coherent phase reference. A base station can also supply the mobile stations in its area with information on the spreading codes employed on the pilot channels of the base stations in the neighboring cells. As a result, the stations are able to recognize transmissions from the neighboring cells. This information may be utilized in carrying out a handoff.

As a mobile station approaches the coverage area border of the current serving base station, the signal from the neighboring cell base station on the same frequency range with the current serving base station begins to appear as ever increasing interference at the receiver of the mobile station. This interference is especially harmful because the spreading codes being employed at the neighboring cells are not necessarily completely orthogonal to the codes in the current cell. In addition, the power control of the neighboring cell base station, if such a power control is in use, does not take adjacent cells into consideration.

In the CDMA system, the connections tolerate interference to a certain degree. To minimize interference, the aim is to keep overlapping of adjacent cells to a minimum. The term overlapping here refers to a simultaneous coverage of the same area by transmission from more than one base station. On overlapping areas

of adjacent cells, the signal strength is relatively weak, and a prior art hard handoff is not very reliable. Hard handoff refers to a handoff in which the existing connection is disconnected before establishing a new one. It is thus a 'break before make' type of a handoff. As the hard handoff is not very reliable in every situation, a so-called soft handoff has been developed in which the terminal equipment for some time communicates with more than one base station simultaneously. A new connection to an adjacent base station is established before breaking the connection to the old one, i.e. it is thus a 'make before break' handoff. In this manner, the reliability of handoffs can be improved.

If a soft handoff between cells is not possible, as is the case e.g. between base stations of different BSCs, the overlapping area between them must be larger than in case a soft handoff were possible. This causes more interference in both cells, which in turn reduces the capacity of the cells.

Previously, an attempt has been made to solving the problem above by avoiding hard handoffs. In a prior art solution, illustrated by examples of Figures 1a-1d, the signal is routed via a mobile services switching center MSC. Figures 1a-1d illustrate the phases of the prior art method. The figures show a diagram of an MSC 100, a first BSS 102, a second BSS 104, and a terminal equipment 106. When approaching the border of the first and second BSC, the terminal equipment 106 has carried out, in a situation of Figure 1a, a soft handoff with base stations of different BSCs 102, 104, thus having a simultaneous connection 108, 110 to different BSSs. As the signals of the different base stations communicating with the terminal equipment must be combined somewhere before the MSC, the signal from the

second BSC 112 must be applied via 114 the MSC 100 to the first BSC in which the combining takes place and from which the coded signal is applied 116 to the MSC 100. At the next phase, 1b, the direct connection 108 is released even though the coding still takes place in the first BSS 102. At the third phase 1c, the transcoding is transferred to take place in the second BSS 104. At the fourth phase, 1d, the connection to the first BSS 102 is disconnected. The drawbacks of the method described include that it requires numerous transmission lines between the various blocks; in addition, the method is complicated and takes up processing capacity from the MSC which is heavily under load as it is.

Summary of the Invention

It is an object of the present invention to carry out a handoff as a terminal equipment particularly moves from one BSS to another so that the drawbacks of the conventional hard handoff can be avoided, and without unnecessarily loading the transmission lines or the MSC.

This object is achieved in a cellular radio system according to the invention, the system employing code division multiple access, and comprising at least one base station in each cell, and a group of base station controllers to each of which is coupled at least one base station, the BSC and the base stations coupled thereto constituting a BSS, and the BSCs controlling the use of radio resources of the base stations coupled to them, and in the system the base stations located at the border of two or more BSSs being coupled to at least two BSCs which control said base station.

The invention in addition relates to a method for performing a handoff in a cellular radio system comprising at least one base station in each cell, and

a group of BSCs and an MSC coupled to them, and in which at least one base station is coupled to each BSC, the BSC and the base stations coupled thereto constituting a BSS, and the BSCs controlling the use of radio resources of the base stations coupled to them, the method comprising the steps of the first BSC transmitting a message on a handoff need by the terminal equipment to the MSC as the subscriber terminal equipment communicates with a base station which is at the border of the first and second BSS, and the control of the radio resources of which takes place from both the first and second BSC when the terminal equipment moves controlled by the first BSC and using its resources from the direction of the first BSC towards the second BSC, the message containing a description on the radio channel of the terminal equipment; the MSC transmitting information to the second BSC on the handoff request received, the information containing a description on the radio channel of the terminal equipment; the second BSC allocating radio resources for the terminal equipment connection on the basis of the message received, and commanding the base station in whose service area the terminal equipment is located to establish a transmission line connection between the second BSC and the base station for the connection of the terminal equipment, and said connection having been established, transmitting an indication thereof to the MSC; the MSC transferring the terminal equipment to under the control and resources of the second BSC, and transmitting a message to the first BSC to release the radio resources related to the connection of the terminal equipment.

The method according to the invention provides several advantages. By the invention, it is possible to avoid a conventional hard handoff, resulting in a better

reliability of the connection particularly at the border of two BSSs. In addition, according to the solution of the present invention, the prior art drawbacks, such as loading the MSC, can be avoided.

Description of the Drawings

In the following, the invention will be described in closer detail with reference to the examples in the accompanying drawings, in which

Figure 1 shows an example of the prior art method described above,

Figure 2 illustrates the structure of the cellular radio system according to the invention,

Figure 3 illustrates the structure of the base station controller and base station according to the preferred embodiment of the invention,

Figure 4 illustrates the structure of the base station controller and base station according to a second preferred embodiment of the invention.

Description of the Preferred Embodiments

A typical cellular radio systems consists of a plurality of base stations, whose service areas are referred to as cells, and base station controllers. The base stations communicate with subscriber terminal equipments over the radio path, are responsible for channel coding, and comprise the required logic for managing these functions, including conveying of information from the terminal equipments to outside the network and vice versa. The base station controllers, in turn, control the functions and radio resources of the base stations. If a terminal equipment communicates with more than one base station simultaneously, as is the case in a soft handoff, the base station controllers also combine signals received by several different base stations.

In the following, an example will be examined of the structure of the cellular radio system according to the invention by means of the chart in Figure 2. The figure shows two BSCs 200, 202 of the cellular radio system, and a group of base stations 204-218. Base stations 204-212 are connected to the first BSC by means of transmission lines 220-230. Further, there is a connection from the BSC to the rest of the network by means of transmission line 242. Thus, the area of the first BSC comprises the BSS covered by base stations 204-212.

By means of transmission lines 238, 240, 248, base stations 214-218 are connected to the second BSC. Further, there is a connection from the BSC to the rest of the network by means of transmission line 244. In the solution according to the invention, the base stations at the border of the BSSs, i.e. base stations 208-212, are connected not only to the first BSC 200 but also to the adjacent, i.e. the second, BSC 202 by means of transmission lines 232-236. Thus, the area of the second BSC correspondingly comprises the BSS covered by base stations 208-218. The resources of base stations 208-212 at the border of the BSSs are shared between both the BSCs. The shared base station only comprises one set of radio frequency parts, as does a normal base station, and from the point of view of cellular planning and the terminal equipment it constitutes just a single cell.

Consequently, a terminal equipment located in the service area of such a shared base station 208-212 may be controlled by either BSC.

In the following, the structure of the BSC and the base station according to the first preferred embodiment of the present invention will be examined by means of Figure 3. The figure shows two BSCs 200, 202 and a base station 210 at the border of the BSSs. The

base station is provided with an antenna 312 which it uses for transmitting and receiving signals from the terminal equipments, a combiner 308 which is coupled to the antenna and which combines different signals with one another, a group of carrier wave units 306a-306b which transfer the signal to be transmitted onto a carrier frequency, and other required radio frequency parts, and corresponding functions for the receiving direction. The base station further comprises a group of channel units 304a-304d which carry out channel coding and decoding, i.e. the required changes between the radio path and the signal to be transmitted to the BSC. These parts can be implemented by methods known by a person skilled in the art. The base station naturally contains other components as well, such as filters and amplifiers, which is obvious for a person skilled in the art, but as they are not essential to the present invention, they are not shown in the figure.

The base station further comprises a control means 310 which controls the operation of the various parts of the base station, and communicates with the BSCs. The base station in addition comprises a prior art transmission line means 302, which transfers the signal between channel units 304a-304d and BSCs 200, 202 by using transmission lines 228, 234.

The BSCs 200, 202 comprise transmission line units 314, 320 which receive a signal from the base stations communicating with the BSC by using transmission lines 228, 234, and forward it to transcoding units 318a-318d, 324a-324d, where the frames are combined and the required transcoding is carried out. From the transcoders, the signal is applied further to the other parts of the network, e.g. to the MSC 300, by means of transmission lines 242, 244. The BSCs further comprise a control processor 316, 322 which

controls the operation of the various parts of the BSC, and communicates with the base stations controlled by the BSC.

In the following, a solution according to the first preferred embodiment of the invention will be examined. This solution is related to the embodiment of Figure 3. It is assumed, as in the example of Figure 2, that there is, within the service area of base station 210, a subscriber terminal equipment 246 which is moving within the cell from the BSC 200 area towards BSC 202 area. The network detects the terminal equipment moving by means of prior art methods, such as signal strength measurements by the terminal equipment of neighboring base stations. It is assumed that terminal equipment 246 communicates not only with base station 210 but also with base station 206.

As the terminal equipment is moving towards the border of base station 210 coverage area on the BSC 202 side, the network, i.e. BSC 200 in this case, detects that there exists a need for a handoff between BSCs. For this purpose, BSC 200 transmits from its control means 316 a command to terminal equipment 246 to disconnect the connection to base station 206. This information is also conveyed via the MSC to base station 206.

BSC 200 transmits information to MSC 300 on the handoff need by terminal equipment 246. This message contains description on the radio channel of the terminal equipment, i.e. information on the base station, the frequency used and the spreading code of the connection. MSC 300 transmits information to the second BSC 202 on the handoff request received, the information containing description on the radio channel of the terminal equipment with the aforementioned details.

On the basis of the message received from the MSC, the second BSC 202 allocates radio resources for the connection of terminal equipment 246, and controls base station 210 to establish a transmission line connection between the second BSC 202 and base station 210 for the connection of terminal equipment 246 on transmission lines 234. The radio resources comprise one of the transcoders 324a-324d and capacity from the transmission line means 320. As soon as said transmission line connection has been established, control processor 322 of BSC 202 transmits information thereof to MSC 300.

MSC 300 transfers terminal equipment 246 to under the control and resources of the second BSC 202, and transmits a message to the first BSC 200 to release its radio resources, i.e. for example the transcoder, related to the connection of the terminal equipment. The connection allocated for the signal of terminal equipment 246 on transmission lines 228 between base station 210 and BSC 200 is also released.

Hence, terminal equipment 246 is now controlled by BSC 202, and it may, if need be, establish a connection to other base stations that are controlled by BSC 202, e.g. base station 214.

In the following, the structure of the BSC and base station according to the second preferred embodiment of the invention will be examined with reference to Figure 4. The figure shows two BSCs 200, 202 and a base station 210 at the border of the BSSs. The internal structure of the base station and the BSCs disclosed is largely similar to what was described in Figure 3. The base station is provided with an antenna 312 which it uses for transmitting and receiving signals from the terminal equipments, a combiner 308 which is coupled to the antenna and which combines different

signals with one another, a group of carrier wave units 306a-306b which transfer the signal to be transmitted onto a carrier frequency, and other required radio frequency parts, and corresponding functions for the receiving direction. The base station further comprises a group of channel units 304a-304d which carry out channel coding and decoding, i.e. the required changes between the radio path and the signal to be transmitted to the BSC. The above parts and connections between them can be implemented by methods known by a person skilled in the art.

The base station 210 further comprises control means 310 which controls the operation of the various parts of the base station 210, and communicate with the BSCs 200, 202. The base station in addition comprises a transmission line means 302, which transfer the signal between channel units 304a-304d and BSCs 200, 202 by using transmission lines 400, 404. The transmission line means 302 can be implemented by prior art methods.

The BSCs 200, 202 comprise transmission line units 314, 320 which receive a signal from the base stations communicating with the BSC by using transmission lines 400, 404, and forward it to transcoding units 318a-318d, 324a-324d, where the frames are combined and the required transcoding is carried out. From the transcoders, the signal is applied further to the other parts of the network, e.g. to the MSC 300, by means of the transmission lines 242, 244. The BSCs further comprise a control processor 316, 322 which controls the operation of the various parts of the BSC, and communicates with the base stations controlled by the BSC. The above parts and connections between them can be implemented by methods known by a person skilled in the art. The BSCs further communicate with one another by means of transmission line 402 connected to

transmission line units 314, 320. The BSCs may also communicate with other BSCs than those shown in the figure.

In the following, a solution according to the first preferred embodiment of the invention will be examined. This solution is related to the embodiment of Figure 4. It is assumed, as in the example of Figure 2, that there is, within the service area of base station 210, a subscriber terminal equipment 246 which is moving within the cell from the BSC 200 area towards BSC 202 area. The network detects the terminal equipment moving by means of prior art methods, such as signal strength measurements by the terminal equipment of neighboring base stations. It is assumed that terminal equipment 246 communicates not only with base station 210 but also with base station 206. Terminal equipment 246 is thus controlled by BSC 200, and BSC 210 forwards the signal from the terminal equipment by means of transmission line 400 to BSC 200, and in the opposite direction as well.

As the terminal equipment is moving towards the border of base station 210 coverage area on the BSC 202 side, BSC 200 detects that there exists need for a handoff between BSCs. For this purpose, BSC 200 transmits from its control means 316 a command to terminal equipment 246 to disconnect the connection to base station 206. This information is also conveyed via the MSC to base station 206.

BSC 200 transmits information from its control processor 316 to MSC 300 on the handoff need by terminal equipment 246. This message contains description on the radio channel of the terminal equipment, i.e. information on the base station, the frequency used and the spreading code of the connection, and also on the transmission line 402 between BSCs 200 and 202. MSC 300

transmits information to the second control processor 322 of BSC 202 on the handoff request received, the information containing description on the radio channel of the terminal equipment with the aforementioned details, and information on the transmission line 402.

Having received the message from the MSC, BSC 202 allocates radio resources for the connection by terminal equipment 246. The radio resources comprise one of the transcoders 324a-324d and capacity from the transmission line means 320. BSC 202 receives a signal from terminal equipment 246 via BSC 200 on transmission line 402. Next, BSC 202 establishes a connection 404 directly to base station 210, and transfers the resources of transmission line 402 onto transmission line 404 connected to the base station, consequently releasing transmission line connection 402 to BSC 200. As soon as said direct connection has been established between base station 210 and BSC 202, control processor 322 of BSC 202 transmits a message thereof to MSC 300.

Having received the aforementioned message from BSC 202, MSC 300 transfers the terminal equipment to be controlled by BSC 202, and transmits a message to control processor 316 of BSC 200 to release the radio resources employed by the connection of terminal equipment 246.

Although the invention has in the above been described with reference to the example in the accompanying drawings, it is obvious that the invention is not restricted thereto, but it may be varied in different ways within the inventive idea of the attached claims.

Claims

1. A cellular radio system employing code division multiple access and comprising at least one base station in each cell, and a group of base station controllers BSC to each of which is coupled at least one base station, the BSC and the base stations coupled thereto constituting a base station system BSS, and the BSCs controlling the use of radio resources of the base stations coupled to them, and in which system the base stations located at the border or two or more BSSs are connected to at least two BSCs which control said base station.

2. A cellular radio system as claimed in claim 1, wherein each of the base stations connected to at least two BSCs comprises at least one transceiver, one or more channel coders, and one or more signalling and transmission line means which are shared between the BSCs connected to the base station.

3. A method for performing a handoff in a cellular radio system comprising at least one base station in each cell, and a group of BSCs and an MSC coupled to them, and in which at least one base station is coupled to each BSC, the BSC and the base stations coupled thereto constituting a BSS, and the BSCs controlling the use of radio resources of the base stations coupled to them, the method comprising the steps of

the first BSC transmitting a message on a handoff need by the terminal equipment to the MSC as the subscriber terminal equipment communicates with a base station which is at the border of the first and second BSS, and the control of the radio resources of which takes place from both the first and second BSC when the terminal equipment moves controlled by the first BSC and

using its resources from the direction of the first BSC towards the second BSC, the message containing a description on the radio channel of the terminal equipment,

the MSC transmitting information to the second BSC on the handoff request received, the information containing a description on the radio channel of the terminal equipment,

the second BSC allocating radio resources for the terminal equipment connection on the basis of the message received, and commanding the base station in whose service area the terminal equipment is located to establish a transmission line connection between the second BSC and the base station for the connection of the terminal equipment, and said connection having been established, transmitting an indication thereof to the MSC,

the MSC transferring the terminal equipment to under the control and resources of the second BSC, and transmitting a message to the first BSC to release the radio resources related to the connection of the terminal equipment.

4. A method for performing a handoff in a cellular radio system comprising at least one base station in each cell, and a group of BSCs and an MSC coupled to them, and in which at least one base station is coupled to each BSC, the BSC and the base stations coupled thereto constituting a BSS, and the BSCs controlling the use of radio resources of the base stations coupled to them, the method comprising the steps of

the first BSC transmitting a message on a handoff need by the terminal equipment to the MSC as the subscriber terminal equipment communicates with a base station which is at the border of the first and second

BSS, and the control of the radio resources of which takes place from both the first and second BSC when the terminal equipment moves controlled by the first BSC and using its resources from the direction of the first BSC towards the second BSC, the message containing a description on the radio channel of the terminal equipment and on the transmission line between the BSCs,

the MSC transmitting information to the second BSC on the handoff request received, the information containing a description on the radio channel of the terminal equipment and on the transmission line between the BSCs,

the second BSC allocating resources for the terminal equipment connection on the basis of the message received, releasing the transmission line connected to the first BSC and coupling it to the base station in whose service area the terminal equipment is located, and said connection having been established, transmitting an indication thereof to the MSC,

the MSC transferring the terminal equipment to under the control and resources of the second BSC, and transmitting a message to the first BSC to release the radio resources related to the connection of the terminal equipment.

5. A method as claimed in claim 3 or 4, wherein the terminal equipments measure the strength of signals transmitted by adjacent base stations, and wherein a decision on handoff need of the terminal equipment is made on the basis of the measurement results.

6. A method as claimed in claim 3 or 4 wherein, when the terminal equipment is simultaneously connected to one or more base stations whose radio resources are not controlled from both the first and the second BSC, the connection to said base station is disconnected prior to carrying out a handoff.

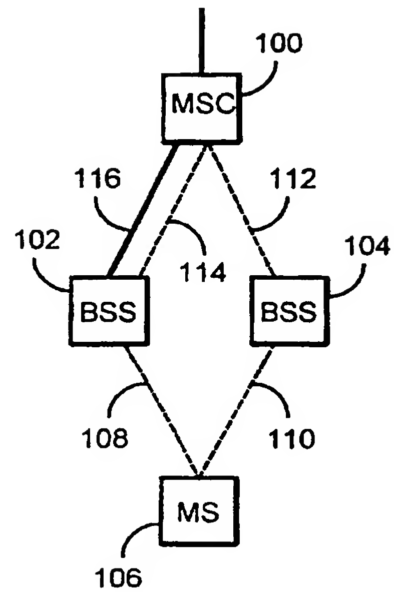

Fig. 1a

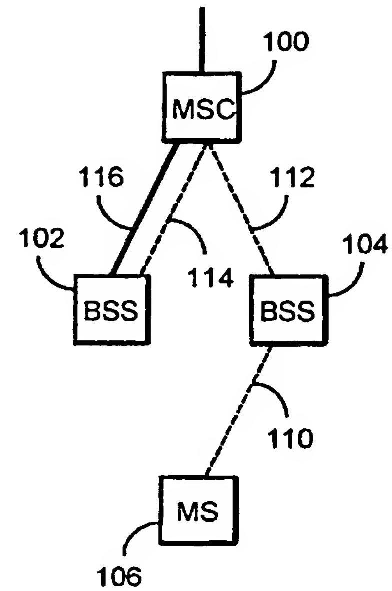

Fig. 1b

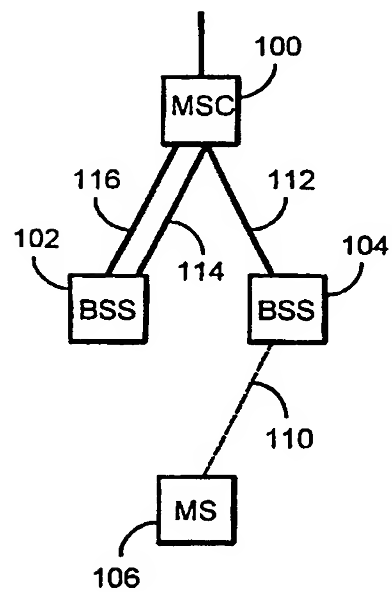

Fig. 1c

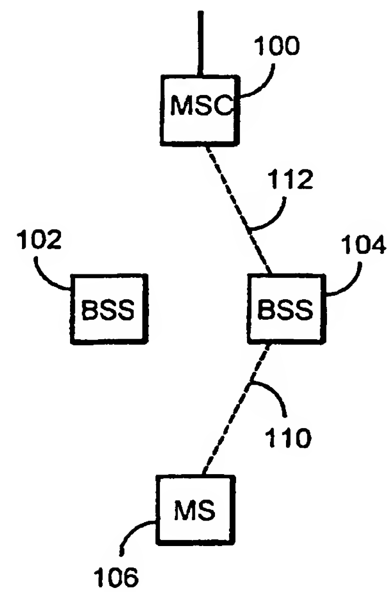

Fig. 1d

PRIOR ART

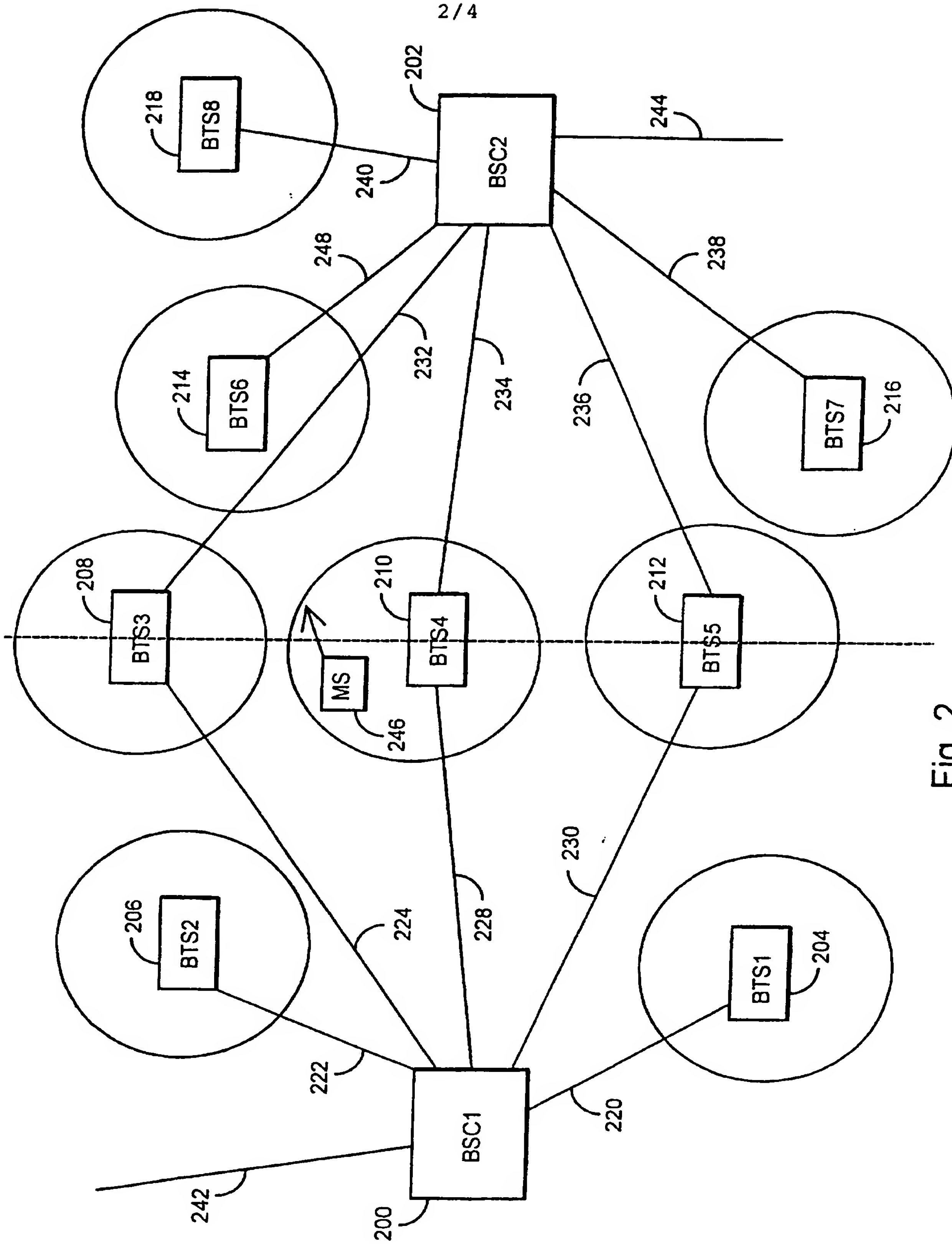
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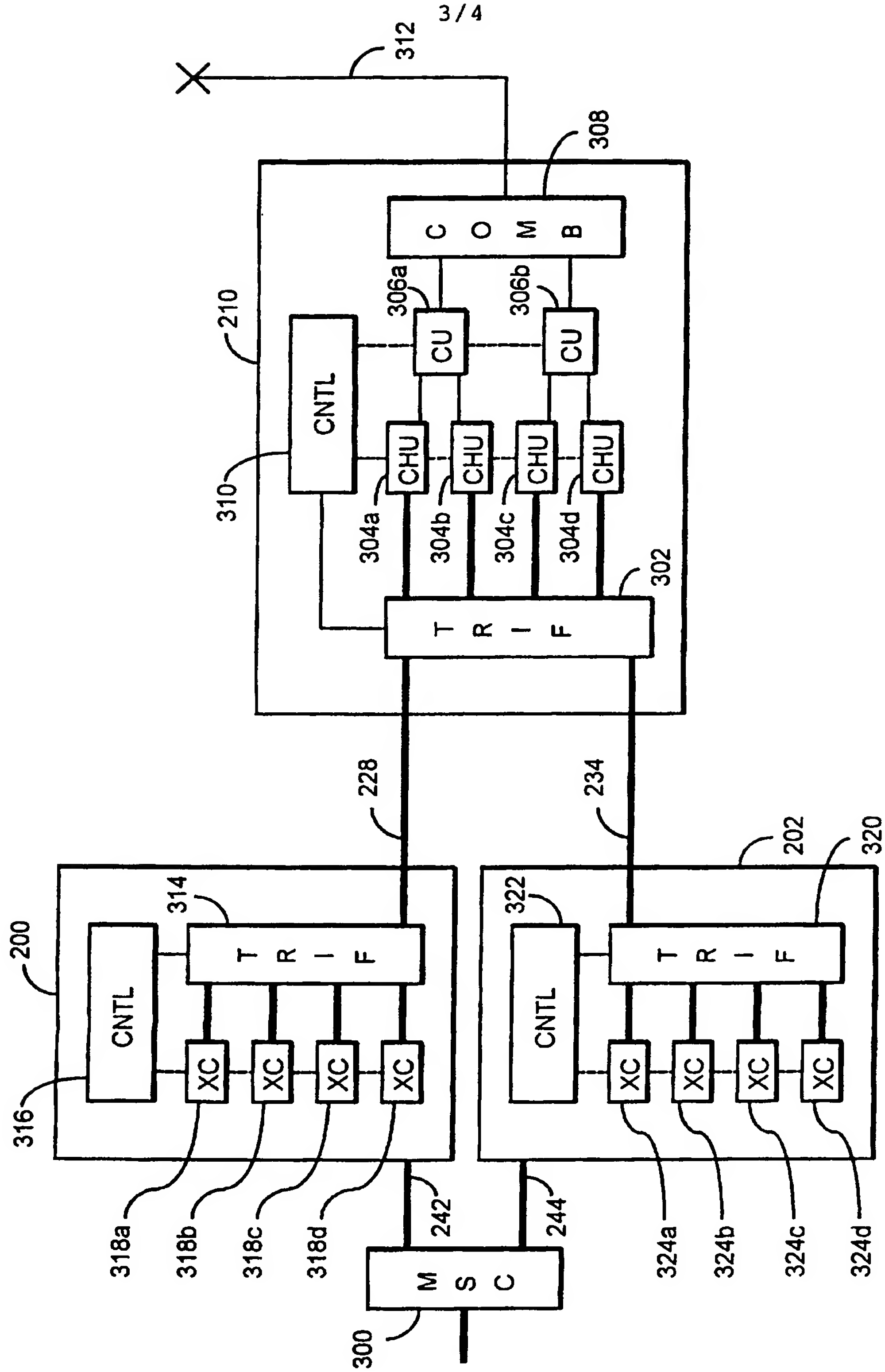
Fig. 2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310
304a
304b
304c
304d
302
T R I F
228
234
202
320
200
314
322
T R I F
T R I F
CNTL
CNTL
XC
XC
XC
XC
XC
XC
XC
XC
316
318a
318b
318c
318d
242
244
M S C
300
324a
324b
324c
324d

Fig. 3

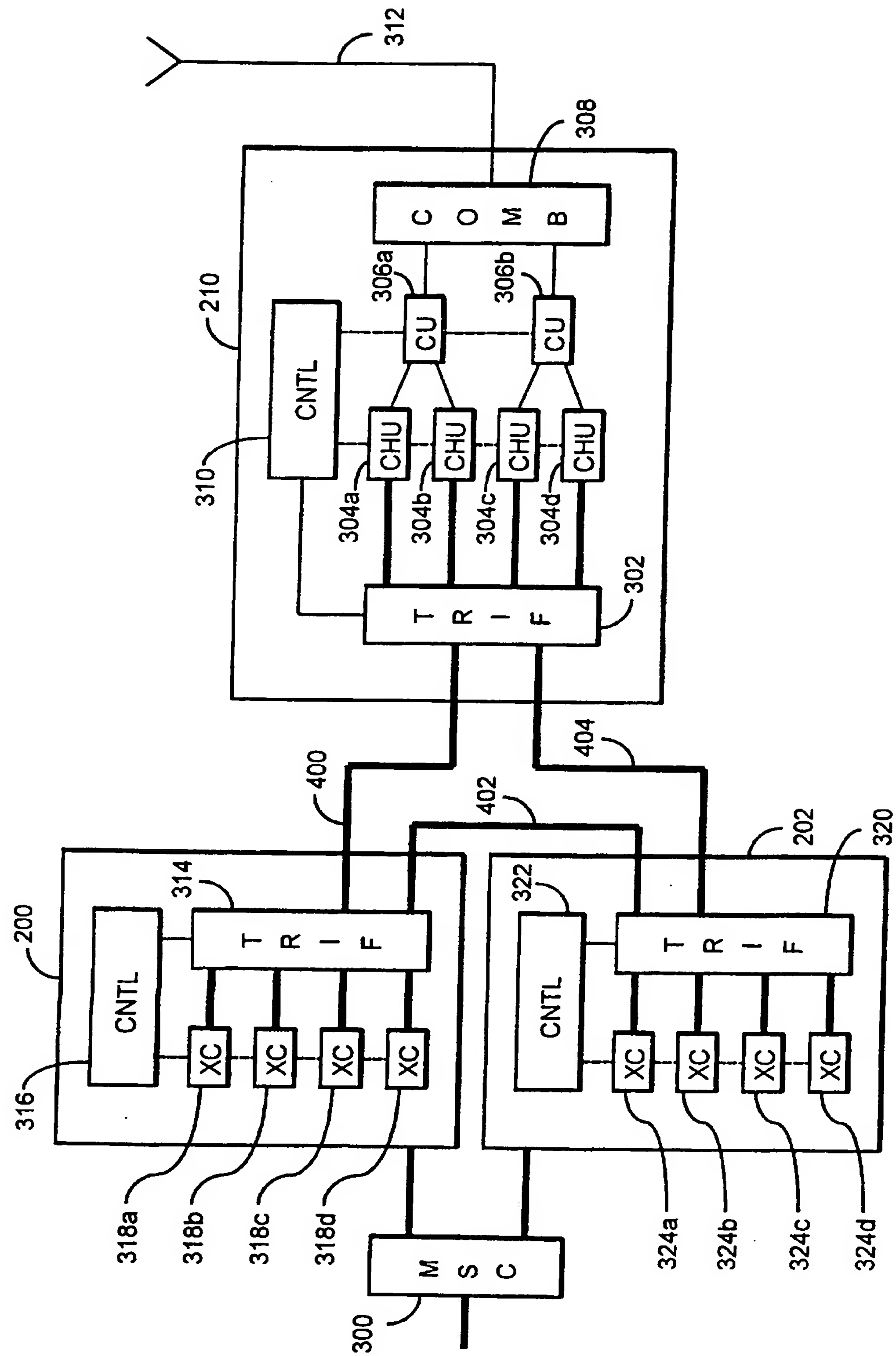
312
308
COMB
210
306a
306b
CU
CU
CNTL
310
CHU
CHU
CHU
CHU
304a
304b
304c
304d
TRIF
302
400
404
402
202
320
200
314
322
CNTL
TRIF
CNTL
TRIF
XC
XC
XC
XC
XC
XC
XC
XC
316
318a
318b
318c
318d
324a
324b
324c
324d
MSC
300

Fig. 4